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COPPER ROOFINGS

THIRD EDITION



♀ A MANUAL ♀

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COPPER ROOFINGS

· INFORMATION · FOR · ARCHITECTS ·
· AND · ROOFING · CONTRACTORS ·



THIRD EDITION
AUGUST
1925

COPPER AND BRASS RESEARCH ASSOCIATION
25 BROADWAY, NEW YORK

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Copper and Bronze Research Association
New York



THE Third Edition of Copper Roofings is practically a new book. The older edition has been thoroughly revised and considerable data has been added. The Description of Different Methods (Part One) has been rewritten and enlarged by additional information. The Specification (Part Two) is now complete, except, of course, for those special conditions which occur in most large roofs. The Notes on Copper Roofing (Part Three) have been rewritten to cover many of these.

In this Edition, Copper Roofings is intended to be a companion book to Copper Flashings. For more complete details than are contained herein the reader is referred to the latter, which describes in detail various flashings, methods of installing built-in gutter linings, proportioning gutters and leaders, and similar items of sheet-copper work.

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THE HISTORY OF THE UNITED STATES

OF AMERICA

The history of the United States is a story of growth and change. It begins with the first settlers who came to the Americas, and continues through the years of exploration, settlement, and the struggle for independence. The story is one of a people who have built a nation of freedom and opportunity, and who have played a leading role in the world.

The early years of the United States were marked by a period of rapid growth and expansion. The country was founded on the principles of liberty and justice for all, and these principles have guided the nation through the years. The story of the United States is a story of a people who have built a nation of freedom and opportunity, and who have played a leading role in the world.

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PART ONE

Application of Copper Roofings

DESCRIPTION OF DIFFERENT METHODS

SLOPING ROOFS

There are two methods of applying copper sheets to sloping roofs, viz.: the Ribbed Seam method, and the Standing Seam method. The difference in these methods is one of construction. In the former wood ribs, or battens, are used to break up the roof surfaces. In general, it is best suited to large monumental buildings. In the

latter the seams forming the longitudinal joints are left standing. This method is used on all types of sloping roofs.

In both the ribbed and standing seam form of roofing there is ample provision for expansion and contraction.

FLASHINGS, GUTTERS, AND DRAINS

Construction details for built-in gutters are found in Fig. 2, Plate 1, and Figs. 2 and 3, Plate 3. The methods of finishing the sheets and seams at the gutter edge and eaves are shown in Fig. 5, Plate 1; Fig. 7, Plate 2; and Figs. 2 and 3, Plate 3.

Several details of flashings are illustrated on Plates 2 and 3. For more complete information consult *Copper Flashings*, 2nd Edition.

In the specification will be found sections covering various kinds of roof drains. Detailed

drawings and descriptions of these will be found on pages 16 and 17 of *Copper Flashings*.

Careful study of all details of flashing and drainage is necessary. For the guidance of the roofing contractor large-scale detail drawings of these features should be made. Roof surfaces seldom give trouble. Gutters and flashings sometimes do, unless the method of application of the copper is carefully worked out.

WHITE LEAD

Attention is directed to Section 21 of the specifications, and to page 23, where the use of White Lead (instead of solder) for closing seams is described.

Thirty or forty years ago this seems to have been common practice in this country, and it still is in Europe. Most of the older roofers are familiar with it, but the younger metal workers are not.

Just why solder should have replaced White Lead in making seams in sheet-metal work has not been established. In the old days, before the manufacturers of White Lead marketed their

product in its present paste form, the roofer bought dry lead and mixed it himself. It was a dirty and laborious practice, which the use of solder did away with.

There is no doubt of the worth of this method of forming seams. Its chief advantages are the saving in labor and material costs. It also aids in concealing the seams, which sometimes spoil the appearance of a copper roof which has weathered to the familiar green. As there is no solder, the seams do not appear as dark streaks on the roof.

RIBBED SEAM METHOD

(Illustrated on Plate 1)

The proper size and spacing of the ribs, or battens, depends on the design of the roof. They are preferably made of cypress, though spruce and North Carolina pine are commonly used. They are usually 2 inches square in section, with sides beveled about $\frac{1}{8}$ inch, firmly secured to the roof sheathing. Provision should be made in the carpenter specification for these ribs.

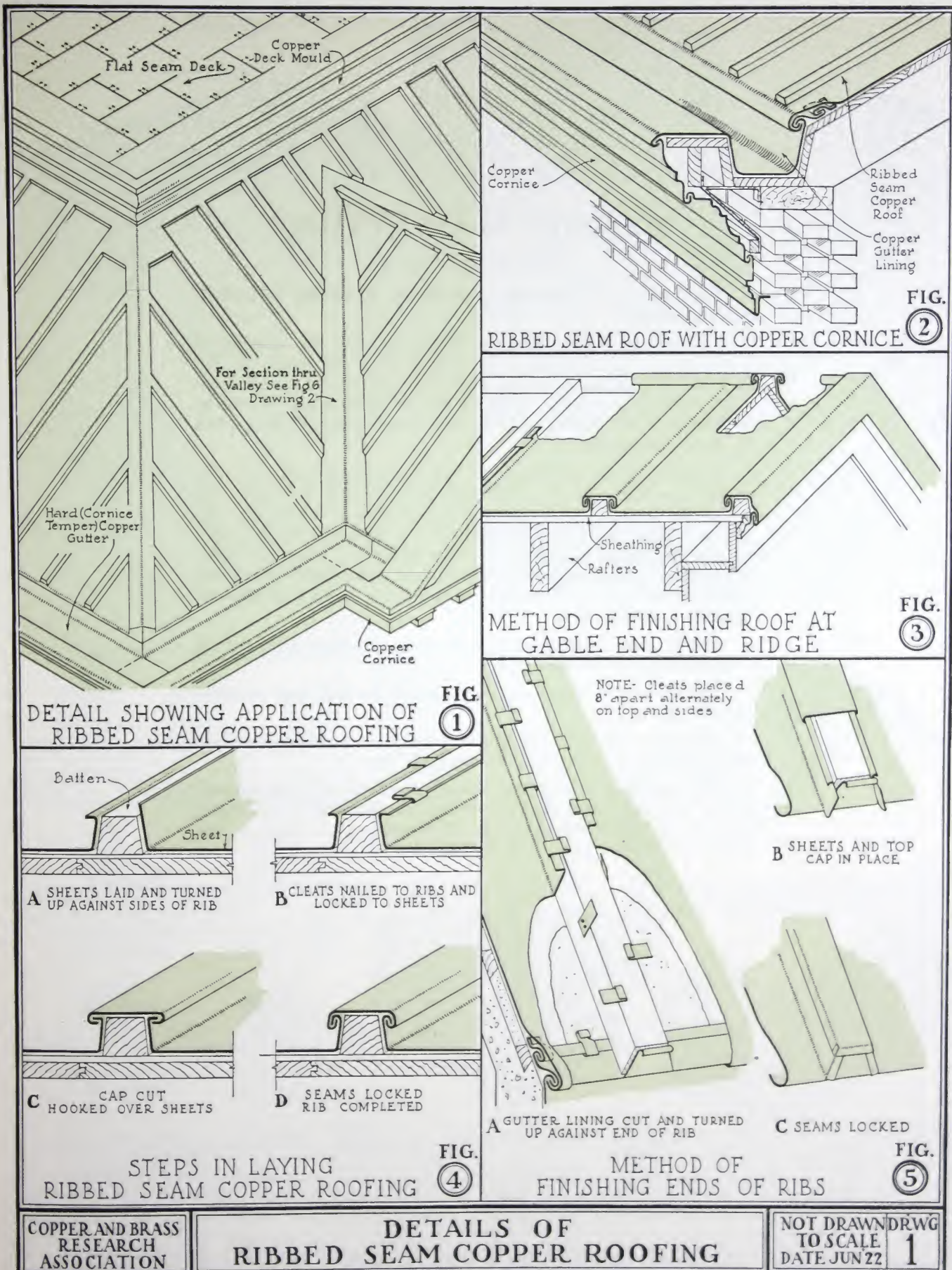
The width of the sheet is dependent upon the spacing and size of the ribs. Copper sheets are stocked in widths in multiples of 2 inches, and the spacing of the ribs should be worked out to fit these widths. Example: If the rib is 2 inches by 2 inches and a spacing of ribs 21 inches, center to center, is desired, the width of the sheet necessary is $21 - 2$ (width of one rib) $+ 2 + 2$ (turn-up of sheet against sides of ribs) $+ \frac{1}{2} + \frac{1}{2}$ (allowances for locks) = 24 inches.

Copper sheets of required width and standard length (96 inches), tinned on the crosswise edges, are laid on the roof between the ribs; the edges of the long dimensions are turned up at right angles to the sheet and are again turned at the top of the vertical leg parallel to and away from the ribs.

These sheets are held in place by copper cleats, spaced at intervals of 8 inches and attached to the top and sides of the wood rib with copper nails, the free ends of the cleats being turned over to engage the edges of the sheets.

The wood rib is then covered with a copper cap of proper width. The edges of this cap engage the edges of the sheets to form half-inch locked seams. At the cross seams the sheets are held in place by soldered locked seams, as in any other form of metallic roofing of this description.

On steep slopes (15 degrees or more) soldered cross seams are not necessary, and the tinning of the crosswise edges can be omitted.



STANDING SEAM METHOD

(Illustrated on Plate 2)

The spacing of the seams is a matter of design and architectural effect.

The width of the sheets is determined by the spacing of the seams. An allowance for seams must be made of $2\frac{3}{4}$ inches. Accordingly a sheet 24 inches wide would give a seam spacing of $21\frac{1}{4}$ inches. Copper sheets are stocked in widths in multiples of 2 inches and the seam spacing should be worked to these dimensions.

Vertical bends are made on the lengthwise edges of the sheets—on one side $1\frac{1}{2}$ inch and on the other $1\frac{1}{4}$ inch, the $1\frac{1}{2}$ -inch vertical bend on one sheet always adjoining the $1\frac{1}{4}$ -inch bend on the adjacent sheet. Copper cleats, attached to the sheathing beneath the edge having a $1\frac{1}{2}$ -inch bend, engage the verticals, which are turned down and locked together as in Fig. 3. The seam so formed is again turned over, forming a double lock.

If a $\frac{3}{4}$ -inch finished seam is desired, the edges are bent up 1 and $1\frac{1}{4}$ inches, respectively.

The crosswise edges are well tinned, locked, and sweated full of solder.

On steep slopes (15 degrees or more) the tinning and soldering of the cross seams may be omitted.

The standing seam allows lateral expansion and contraction in the space between the two vertical sections above the plane of the roof and below the lock. It should not be used on flat roofs, for, being unsoldered, it is not water-tight.

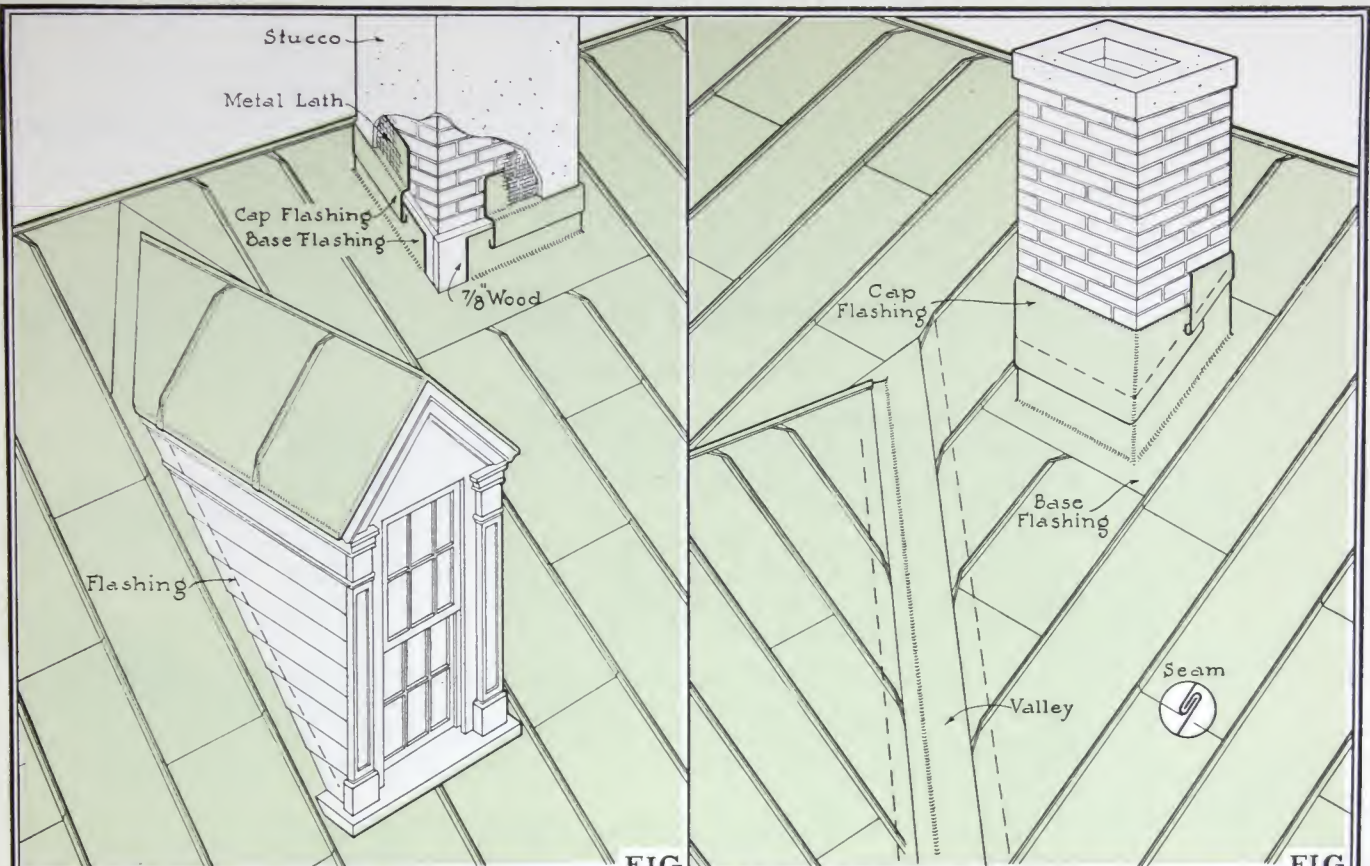


FIG. 1 DETAIL SHOWING METHOD OF FLASHING AROUND DORMER AND STUCCO CHIMNEY

FIG. 2 DETAIL SHOWING METHOD OF FLASHING AROUND VALLEY AND BRICK CHIMNEY

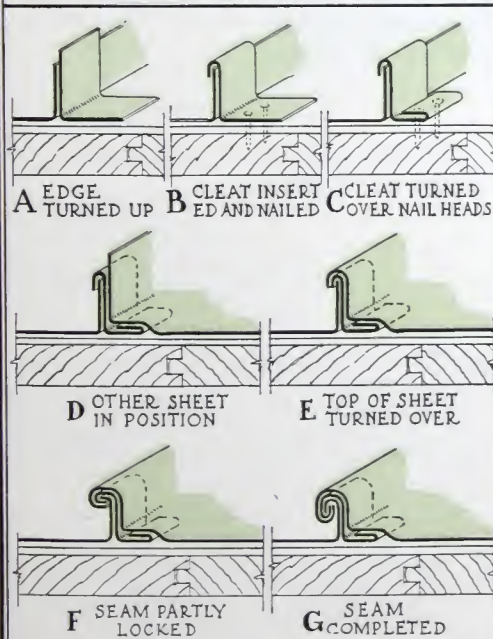


FIG. 3 STEPS IN LAYING A STANDING SEAM COPPER ROOF

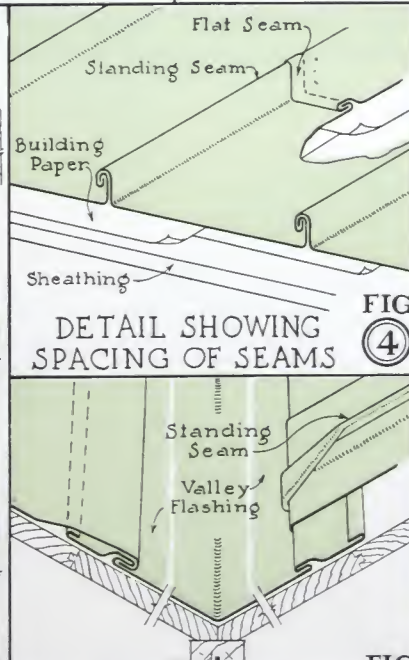


FIG. 4 DETAIL SHOWING SPACING OF SEAMS

FIG. 6 DETAIL SHOWING STANDING SEAM AT VALLEY

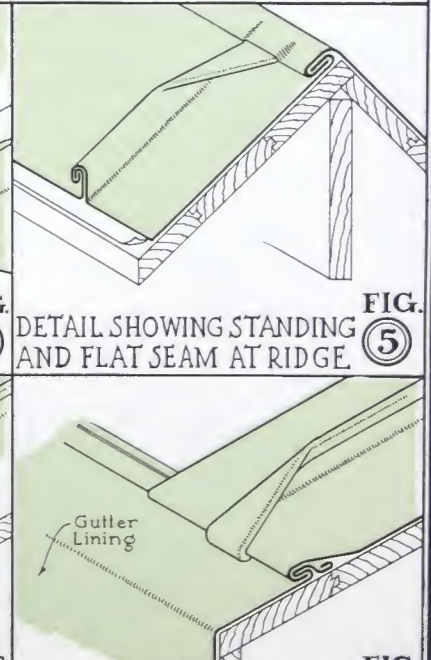


FIG. 5 DETAIL SHOWING STANDING AND FLAT SEAM AT RIDGE

FIG. 7 DETAIL SHOWING STANDING SEAM AT GUTTER

NOTE—ALL SEAMS HAVE BEEN EXAGGERATED TO SHOW CLEARLY METHOD OF LAYING

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DETAILS OF STANDING SEAM COPPER ROOFING

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FLAT SEAM METHOD

(Illustrated on Plate 3)

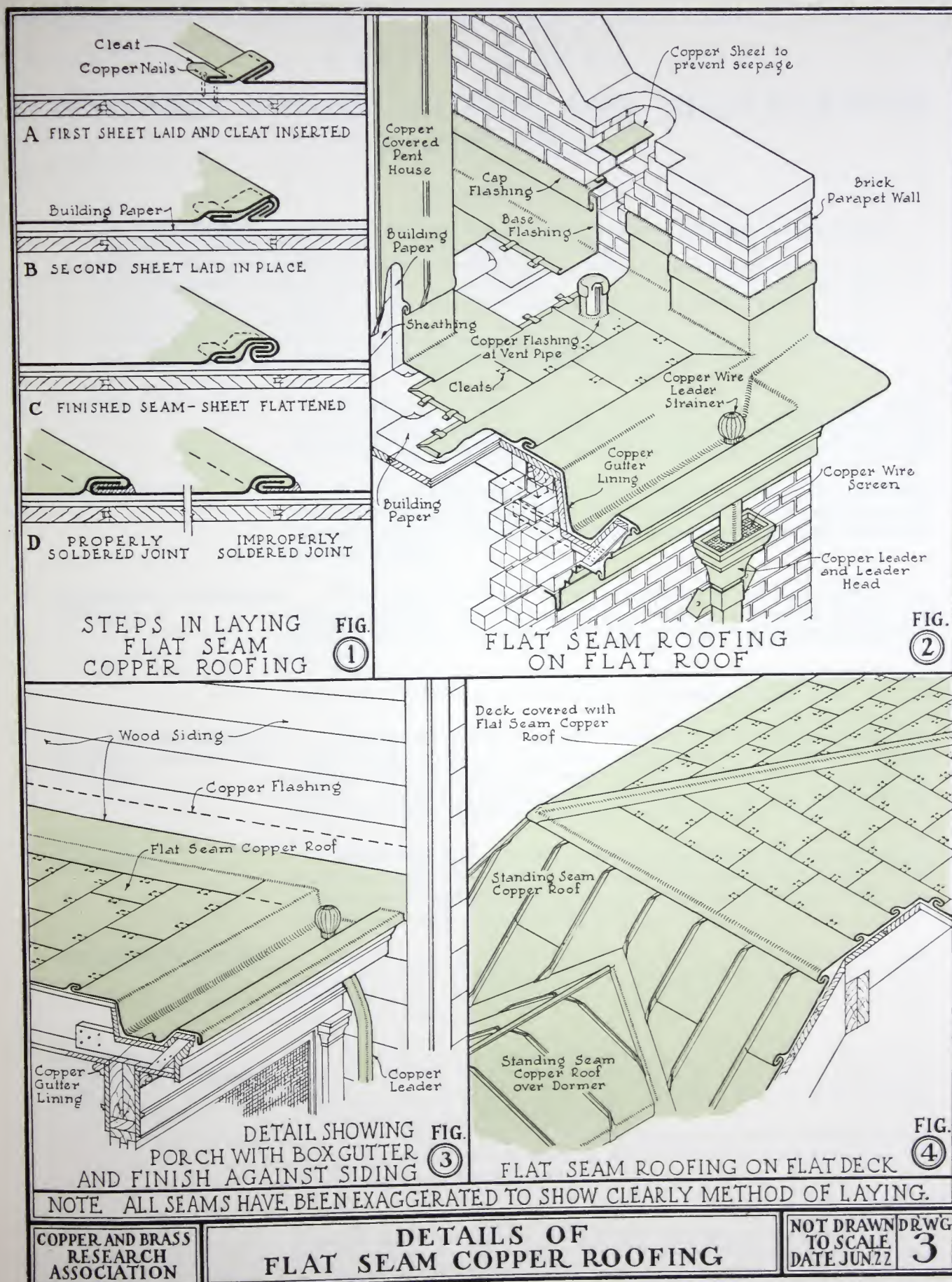
Small sheets, with $\frac{1}{2}$ -inch seams, flat-locked and soldered, are used for flat roofs (less than 1 on 3) and decks. The size of sheet which best combines economy and practicability, is about 18 by 24 inches.

The sheets are tinned on all edges and are then formed as required to make $\frac{1}{2}$ -inch locks with adjacent sheets. Each sheet is held in place by copper cleats and the seams are then malletted down and soldered. (Fig. 1.)

As no nails are driven through the sheets, they are free to move and all stress from expansion is taken up by the cleats. This stress is scarcely appreciable in any one cleat, and, as the cleats are uniformly distributed over the roof, expansion is amply provided for.

If there is no likelihood of water collecting on the roof, because of clogged outlets, white lead, instead of solder, can be used for closing the seams.

All flat enclosed roof surfaces, such as balcony decks, should be built with scuppers in the enclosing walls so that water will not back up and freeze in the winter when the outlet is obstructed.





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PART TWO

STANDARD SPECIFICATIONS FOR SHEET-COPPER ROOFINGS

NOTES

1. Alternate Methods of doing work are listed in order of recommended practice. In every case the first listed (letter A) describes recommended best practice.
2. Different Methods for different kinds of construction are collected under one general heading: the paragraphs have been sub-numbered 1, 2, 3, etc.
3. The arrangement of subjects has been made to agree, as nearly as possible, with the usual arrangement of sheet-metal specifications for the average building.
4. For the convenience of the specification-writer paragraphs have been numbered consecutively, and all Alternates and Different Methods have been given a designating legend.

1. General.

The General Conditions of the contract are hereby made a part of the contract and this contractor shall examine these General Conditions and thoroughly acquaint himself with all the requirements therein contained.

2. Scope of Work.

Except as otherwise specified this contract includes the furnishing of all labor and materials necessary to complete in every respect in accordance with the best practice all the sheet-copper work of every description for this building.

3. Contractor to Examine Surfaces.

This contractor shall carefully examine all surfaces prepared for roofing, flashings, etc., by other trades, shall point out all defects, and shall see that the necessary corrections are made before proceeding with his work.

This contractor shall arrange his work so as to co-operate at all times with other trades and prevent delay or damage to other work.

4. Precautions against Damage during Construction.

During construction care shall be taken to prevent damage to sheet-copper work in place by walking or placing heavy materials on it. As soon as soldering is done, the work shall be cleaned of all injurious substances. Toward completion, all work shall be repaired, shall have all stains and debris removed, and shall be left in perfect condition.

5. Guarantee.

Before final payment the contractor shall give to the owner a written guarantee which shall specify the kind, weight and manufacturer of the materials used, and shall guarantee all workmanship against failure for a period of 5 years after the acceptance of the work.

6. Preparation of Surfaces.

Before applying copper to any surface the roofing contractor shall inspect same and make sure that it is smooth and even and free from all small projections and hollows. He shall give notice, before starting work, of any defects.

7. Sheathing. (Carpenters' Specification.)

All sheathing upon which sheet copper is to be laid shall be of straight, unwarped boards, free from splits and knot holes. All joints shall be true and even. All nail heads shall be set. All uneven edges of boards shall be smoothed off to give a firm, even surface.

Notice shall be given to the roofing contractor when the sheathing is laid and an inspection shall be made by him. All defects observed at this inspection shall be corrected promptly.

8. Building Paper.

Before laying copper all surfaces shall be covered with building paper of approved quality, rosin-sized, or asbestos, weighing not less than 6 pounds per 100 square feet. Paper shall lap 2 inches and be nailed with large flat-head copper nails.

9. Sheet-Copper.

Where shown on drawings or described in these specifications all sheet-metal of every description shall be of copper.

All copper sheets used shall be rolled from copper conforming to the Standard Specifications of the American Society for Testing Materials.

All copper sheets shall be plainly marked with the manufacturers' name and the weight.

10. Soft (Roofing Temper) Copper.
Hard (Cornice Temper) Copper.

Except as otherwise specified, all copper throughout the work shall be of 16-ounce, soft (roofing temper) copper sheets.

All leaders, eaves troughs, and molded hanging gutters shall be of 16-ounce, hard (cornice temper) copper.

11. Tin.

All tin used for tinning seams for soldering, etc., shall be best grade, pure metal.

12. Solder.

All solder shall be of the best grade, equal to Specification B-32 of the American Society for Testing Materials, and shall be composed of one-half pig lead and one-half block tin (new metals).

13. Flux.

Rosin shall be used as a flux.

14. Nails and Fastenings.

All nails, rivets and similar fastenings used throughout the work shall be of best grade hard copper or brass.

Nails shall be wire nails not less than No. 12 gage and not less than $\frac{7}{8}$ inch long.

15. Tinning.

The edges of all sheets to be soldered shall be tinned $1\frac{1}{2}$ inches on both sides. Rosin shall be used as a flux.

16. Soldering-Coppers.

All soldering shall be done with heavy soldering-coppers of blunt design, properly tinned before use. They shall weigh not less than 6 pounds to the pair. For flat-seam work on decks, in gutters, etc., they shall weigh not less than 10 pounds to the pair.

17. Soldering.

Soldering shall be done slowly with well-heated coppers so as to thoroughly heat the seam and completely amalgamate the tin with the solder. Plenty of solder shall be used and the seam shall show when finished at least one full inch of thick, evenly-flowed solder.

18. Slopes of Roofs.

On roofs having a slope of less than 1 on 4 all flat and lap seams shall be soldered. On roofs having a slope of 1 on 4 or greater, flat and lap seams shall not be soldered.

19. Seams.

Standing Seams shall finish not less than 1 inch high.

Flat, or Lock, Seams shall finish not less than $\frac{1}{2}$ inch wide.

Lap Seams, where soldered, shall finish not less than 1 inch wide.

Lap Seams not soldered shall lap at least 3 inches.

All Flat and Lap Seams shall be made in the direction of the flow.

20. Loose-Locked Seams.

Where, on copper-covered surfaces, an intersection of roof planes, or an abrupt change of slope, shall occur, the joint between the sheets on the two surfaces shall be an unsoldered, loose-locked seam similar to a standing seam hammered flat, or a double lock seam. It shall be placed as close to the line of intersection as possible and shall be so formed as to preclude leakage. It shall not be fastened to the roof, except that at the cross seams of the sheets so joined cleats may be set close to the loose-locked seam.

21. White Lead.

Except on copper-covered surfaces where water can accumulate and remain, white lead shall be used in all flat and double-locked seams.

White lead shall be composed of basic lead carbonate, conforming to

specification D81-24 of the American Society for Testing Materials, and shall be in paste form. If necessary the paste shall be mixed with sufficient pure boiled linseed oil to give it a putty-like consistency free from lumps and skins.

The locks formed in the sheets shall be buttered plentifully, and the sheets shall then be joined together in the usual way to form locked seams as specified elsewhere. All excess white lead squeezed out of the seam in the process of forming shall be carefully removed from the roof. Upon completion the seams shall have solid, even layers of white lead between the folds of the metal.

22. Crimped Copper.

All copper sheets shall be crimped by passing through heavy rolls to form 3/16-inch ridges in the sheets in the direction of the short dimension.

23. Cleats and Fastenings.

All sheets over 12 inches wide shall be fastened by cleats 1½ inches wide and about 3 inches long, spaced as specified elsewhere. They shall be secured to the roof by two nails set about ¾ of an inch from the end and shall have the end turned back ½ inch over the nail heads. The free end of the cleat shall be turned over ½ inch to engage the edge of the sheet and shall be locked into the seam. Where seams are soldered cleats shall be tinned. Except as otherwise specified cleats shall be spaced not more than 12 inches apart. 18 x 24-inch sheets shall have two cleats on the long side and two on the short side of each sheet.

Where copper is laid on concrete or gypsum roof slabs the roofing contractor shall prepare detailed instructions, with drawings, etc., for locating all fastenings for cleats, edge- and eaves-strips, flashings, etc.

24. Fastenings for Copper Roofing. (Mason's Specification.)

In all concrete or gypsum roof slabs which are to be covered with copper roofing or flashings set fastenings for cleats, edge- and eaves-strips, etc., as located by the sheet-metal contractor. Fastenings shall consist of (1) 2 x 2-inch nailing strips placed in the roof slab flush with surface; (2) wood grounds placed in the roof slab at eaves, etc.; (3) expansion inserts to receive nails or screws.

Before the roof slabs are poured this contractor shall obtain from the sheet-metal contractor complete instructions, with drawings, for locating fastenings.

25. Ribbed (Batten) Seam Roofing.

All wood ribs shall be set under another contract to the spacing shown on the drawings. The roofing contractor shall see that these are well secured with all nails well set, truly lined and evenly spaced, and shall not proceed until all faults have been corrected.

In general sheets shall be 96 inches long and shall be laid with cross seams staggered. They shall be fastened by cleats spaced 8 inches apart and secured alternately to the top and side of the ribs. The cleats shall be locked to the sheet and the ribs shall be covered with a flashing cap locked over the cleats and edges of sheets on both sides.

All cross seams shall be flat-locked, and (1) thoroughly sweated with solder, as specified under "Slopes of Roofs," (2) filled with white lead. They shall be secured by cleats.

26. Battens or Ribs for Copper Roofing. (Carpenters' Specification.)

Where indicated on the drawings place on the roof sheathing cypress battens or ribs shaped as detailed. The spacing of these ribs is approximately inches. The exact spacing shall be determined by the architect, and this contractor shall use a templet or gage-board to insure proper lining and spacing. They shall be firmly nailed with all nail heads set.

27. Standing Seam Roofing.

Seams shall be spaced as shown on the drawings.

All sheets shall be, in general, full length. They shall be laid with long edges turned up to form standing seams, and shall be secured by

(Continued on next page)

(§27 continued)

cleats. No solder shall be used on standing seams. Cross seams shall be staggered.

All cross seams shall be flat-locked, and shall be (1) soldered as specified under "Slopes of Roofs"; (2) filled with white lead. They shall be secured by cleats.

28. Flat Seam Roofing.

The roofing shall be applied the narrow way, joints staggered, using sheets not larger than 18 by 24 inches. All sheets shall be properly notched and bent to form flat seams. Each sheet shall be secured to the roof with $1\frac{1}{2}$ by 3-inch copper cleats evenly distributed along the edges of the sheet, as specified elsewhere.

(-1) All sheets to be soldered shall be tinned at least $1\frac{1}{2}$ inches wide all around and on both sides.

(-2) Where white lead is used in the seams tinning shall be omitted.

29. Valleys.

All valleys shall be made with long sheets having no longitudinal seams. They shall be of sufficient width and so cut that the valley shall be 4 inches wide at the top and increase in width from top to bottom at a rate of 1 inch to 8 feet. They shall have their edges turned back $\frac{1}{2}$ inch, shall be secured with cleats, and shall lock with the roofing sheets to form a water-tight joint.

30. Flashings — Where Required.

All intersections of roofs with vertical surfaces of every kind, and all openings in roof surfaces, shall be flashed with copper. The method of flashing, except as otherwise shown or specified, shall be base and counter-, or cap, flashing.

31. Continuous Flashings.

Where the design or construction is such that the base and counter-flashing method is impracticable, flashings shall be made continuous from the roof surface up and into the vertical surface. Flashings of this type shall be generally in two or more pieces, soldered together. Where possible the joints shall be made by flat or double lock seams. Otherwise lap seams shall be used.

32. Base Flashings.

Unless otherwise specified or shown on the drawings base flashings shall be at least 4 inches high, and shall project at least 4 inches out on to the roof. Flashings shall be, in general, full pieces 96 inches in length. On sloping roofs they shall lap longitudinally at least 3 inches. On flat roofs the joints shall be flat-locked.

33. Cap or Counter-Flashings.

Cap or counter-flashings shall extend into masonry walls not less than 4 inches, and be turned down over base flashings not less than 4 inches, with edges turned back $\frac{1}{2}$ inch.

Step flashings shall be used where vertical surfaces occur in connection with pitched roofs. Steps shall lap not less than 2 inches.

Flashings around all shafts and skylights shall be extended up the full height of curbs and properly locked to edges or gutters.

All pipes passing through the roof shall be flashed and counter-flashed with copper. Flashings shall extend out not less than 6 inches on the roof and shall be turned up not less than 8 inches against the pipes. The counter-flashing shall be (1) caulked into hubs of pipes; (2) embedded in white lead and held with brass clamps; (3) formed into a cap or bonnet to fit over the pipe, turning into the pipe 2 inches and lapping the base flashing 5 inches.

**34. Flashings.
(Masons' Specification.)**

Where indicated on the plans or specified build in all flashings furnished by the sheet-metal contractor and as directed by him.

35. Reglets.

Where indicated on the drawings or where directed by the architect flashings shall finish in reglets in the masonry cut by others where located

by this contractor. Flashings shall be worked into reglets the full depth and shall be turned back to form a hook.

After flashings are in place reglets shall be filled and caulked, using molten lead on flat surfaces, and lead wool on vertical surfaces. After caulking reglets shall be made smooth by filling with elastic cement.

**36. Reglets.
(Masons' Specification.)**

Where indicated on the drawings or directed by the architect cut reglets in the masonry as located by sheet-metal contractor for the insertion of flashings. Reglets shall be not less than 1 inch wide and 1 inch deep. They shall be cut with true and straight edges, with sides and bottom roughened.

37. Built-in Gutter-Linings.

Where indicated on the drawings line all box or built-in gutters with copper. Gutter-linings shall fit loosely and shall have the back edge 3 inches higher than the front edge.

(-A.) Small sheets shall be laid with seams staggered. All seams shall be flat locked and soldered. Sheets shall be secured by cleats.

(-B.) Large sheets used to form gutter-linings shall be laid the long way of the gutter. The ends of the sheets shall be locked to cross strips about 4 inches wide by flat or double-locked seams fastened by cleats.

Great care shall be exercised to avoid any sharp bends or creases in the linings at the sides, and to this end sheets formed in the shop for linings shall not be bent more than 90 degrees. In so far as is possible all linings shall be formed on the job from flat sheets.

All gutter-linings over 24 inches wide shall have a longitudinal seam running the length of the gutter of flat or double-locked type, soldered and secured by cleats.

Linings shall be connected to the roofing sheets by large loose-locked seams, folded flat and so placed as to avoid any possibility of leakage. In general the connection shall be made as close to the intersection of the roof slope and the inside of the gutter as is possible.

The back edge of all gutter-linings finishing against vertical walls shall be carried 4 inches above the outside edge of the cornice and shall be covered by cap flashings built into the wall.

(-1.) Gutter-linings in WOOD CORNICES shall have the front edges turned under the lower edge of an $\frac{1}{8}$ x $1\frac{1}{4}$ -inch brass strip screwed to the vertical face of the top member of the cornice. This strip shall be so placed as to form a proper drip.

(-2.) Gutter-linings set in STONE CORNICES shall be placed over a wood sheathing forming the slope of the gutter. The outer edge shall be secured in a reglet. Where the wash slopes out, and where the width of the outer sheet of the lining exceeds 20 inches, a standing seam shall be formed as close as is possible to the reglet.

(-3.) Gutter-linings in CONCRETE OR BRICK WORK shall be secured to battens or nailing strips set by other contractors according to directions by this contractor.

(-4.) Gutter-linings formed back of COPPER CORNICES shall have the front edge locked to the top edge of the cornice over a $\frac{1}{8}$ x $1\frac{1}{4}$ -inch brass strip.

**38. Built-in Gutters.
(Carpenters' Specification.)**

(-1.) Form gutters as shown on the plans, and as directed by the architect, of $\frac{1}{8}$ -inch boards with nail heads set and all surfaces smooth. Consult with the sheet-metal contractor on all details in connection with his work.

(-2.) Set wood blocking and $\frac{1}{8}$ -inch sheathing in masonry gutters as shown on the plans and directed by the architect to form backing for lining sloped to outlets. Make all surfaces smooth with nail heads set. Consult with the sheet-metal contractor on all details in connection with his work.

**39. Built-in Gutters.
(Masons' Specification.)**

Cut all reglets for gutter-linings as shown on plans or directed by the architect. Set all battens and nailing strips in masonry necessary for the

(Continued on next page)

(§39 continued)

sheet-metal work. Form all depressions in masonry for outlet boxes as shown on the plans. Form slopes to outlets in gutters and back of projections which are flashed.

All concrete surfaces to be covered with flashing shall be washed smooth with neat cement. Where cinders have been used in the concrete it shall be painted with two heavy coatings of asphalt paint.

Consult with the sheet-metal contractor on all details in connection with his work.

40. Molded Gutters.

Molded gutters of the size and design shown shall be installed where indicated on the drawings. They shall have a flange which shall extend up on the roof and be flat-locked to the roof sheets, and shall be held in place by cleats 30 inches apart.

The outer edge of the gutter shall be stiffened by a brass rod or rectangular bar, and provided with a proper drip. Braces of heavy copper or brass, spaced 30 inches, shall be locked around or riveted to the outer edge, and secured to the roof sheathing above the flange or flashing by 2 brass screws. These shall be placed before the roof sheets are laid and shall be made water-tight by a special cap soldered to the roof sheets and extending over the braces.

Joints of molded gutters shall be soldered. They shall lap 1 inch and be secured with rivets spaced 1 inch.

Outlets shall be provided with tubes soldered to the gutter.

41. Eaves Trough and Hangers.

Eaves trough, or half-round hanging gutters, of the size and type shown, shall be installed where shown on the drawings. They shall be in 10-foot lengths and shall be joined by 1-inch lapped and soldered joints, or by slip joints. All joints shall be made in the direction of the flow.

Eaves trough shall be provided with end pieces, end caps, outlet tubes and mitres as required.

Eaves trough shall be supported by (1) copper or brass strap or rod hangers of approved design; (2) heavy copper wire hangers; or (3) cast brass hook-type hangers.

(-1.) Strap and rod hangers shall be spaced not more than 36 inches apart and shall be secured to the roofing by brass screws.

(-2.) Wire hangers shall be spaced not more than 24 inches apart and shall be secured to the roofing by heavy copper nails.

(-3.) Cast brass hangers shall be adjustable for slope and shall be spaced not more than 36 inches apart. They shall be secured by brass screws.

42. Outlets for Built-in Gutters.

Outlets shall be formed as shown on the drawings. The gutter lining shall be turned into them and secured by soldered lap seams.

Holes shall be cut as soon as the lining is placed and temporary spouts shall be put in until the permanent drainage is ready.

Outlets shall be connected to leaders by

(-A.) a 20-ounce copper tube;

(-B.) a 4-pound lead gooseneck.

Connections shall be flanged at the top and soldered to the outlet-box lining; the bottom shall have soldered to it a brass ferrule or caulking ring furnished by the plumbing contractor.

43. Roof Drains.

(-A.) Approved types of patented roof drains may be used. They shall be furnished and set by the plumbing contractor and connection shall be made to them by the sheet-metal contractor in strict accordance with the manufacturer's directions.

(-B.) Roof drains shall consist of a circular or square pan whose diameter or side shall measure at least 4 inches greater than the outlet, and have a depression of not less than 1½ inches. They shall have a flashing extending out on roof surfaces, on all sides of the pan, not less than 6 inches. The flashing shall be flat-locked and soldered to the roofing sheets.

(-C.) Roof drains shall consist of a copper flange extending out on the roof on all sides a distance at least equal to the size of the outlet. The flange shall be flat-locked and soldered to the roofing sheets.

Outlets from drains shall consist of

(-A.) a 20-ounce copper tube, soldered to the (A) pan; (B) flange, and (1) extending into the drain pipe at least 6 inches with the outside coated with asphaltum; (2) with a brass ferrule or caulking ring soldered to the end for connection to the drain pipe by the plumbing contractor.

(-B.) a 4-pound lead gooseneck, flanged at the top and soldered to the (A) pan; (B) flange. Connections to the drain pipe shall be made by the plumbing contractor.

44. Roof Drains and Gutter Outlets.
(Plumbers' Specification.)

(-1.) *Furnish the sheet-metal contractor all brass ferrules necessary for connecting the drainage system and the roof drains and outlets shown on the plans, and connect copper tubes fitted with these ferrules to the drain pipes by caulked and leaded joints.*

(-2.) *Where shown on the plans furnish and install 4-pound lead goosenecks of a length necessary for the sheet-metal contractor to make a proper connection to the outlet-box or roof drain, and with a brass ferrule or caulking ring for connecting to the drain pipe.*

(-3.) *Furnish and install complete with all piping connections the patent drains shown on the plans. Make provision, where necessary, for the work of other trades in connecting to the drains.*

45. Wire Strainers.

(-A.) All gutter outlets shall be fitted with approved copper wire strainers of the basket-type set in loose.

(-B.) All gutter outlets shall be fitted with No. 14 gage copper wire strainers of the basket-type set in loose. Vertical wires shall be spaced $\frac{1}{2}$ inch, and shall be reinforced with horizontal wires 3 inches apart, extending around the basket, with each joint soldered.

46. Cast Strainers.

All outlets from gutters and roofs shall be provided with heavy, cast brass, removable strainers the full size of the outlet-box.

47. Leaders, Conductors, or Downspouts.

Leaders shall be installed where shown on the drawings, of the shapes and sizes indicated. They shall be held in position, clear of the wall, by

(-1.) Brass hooks, driven into the wall not more than 6 feet apart.

(-2.) Heavy brass or copper straps, $\frac{1}{8} \times 1\frac{1}{2}$ inches, spaced not more than 6 feet apart, soldered to the leaders, and fastened (1) to wood work by brass screws; (2) to masonry by brass screws set in lead sleeves.

(-3.) Ornamental straps of (1) stock design; (2) the design shown, and made of (1) hard (cornice temper); (2) soft (roofing temper) copper.

Leaders shall be in 10-foot lengths, and shall be lapped, tinned inside and out, and soldered. A $1\frac{1}{2}$ -inch slip joint shall be provided every 20 feet of leader.

When leaders connect with underground drains they shall be fitted into drain pipes and shall have the joint neatly cemented. All leaders not so connected shall have elbows at the bottom. Those discharging at ground level shall have heavy shoes with reinforced ends.

48. Leader Heads.

Leader heads of (1) stock design; (2) the design shown, shall be placed where indicated on the drawings. Outlet tubes from gutters shall extend into them about 2 inches. The bottom of the leader head shall be soldered to the leader.

Large leader heads (12 inches wide or over) shall have a heavy copper-wire removable screening over the top.

49. Skylights.

Where shown on the drawings build skylights of size indicated and of approved design and manufacture, with curbs at least 10 inches above the roof. All sheet metal shall be 16-ounce hard (cornice temper)

(Continued on next page)

(§49 continued)

copper, reinforced for strength and stiffness with steel sections. Copper and steel shall be insulated by strips of 3-pound lead or by an asbestos covering on the steel. All sash bars and bearings for glass shall have condensation gutters leading to the outside of the skylight. All skylights shall be made water- and weather-tight with joints interlocked, riveted and soldered, and shall conform to the requirements of the National Board of Fire Underwriters. Duplicate sets of detail drawings shall be submitted for approval.

50. Cornices.

Where shown on the drawings cornices shall be erected of 20-ounce hard (cornice temper) copper. They shall be made in strict accordance with the profiles shown on drawings with moldings true, sharp and straight. All flat surfaces over 5 inches wide shall be crimped, all mitres and joints carefully fitted, angles and corners reinforced, and all joints neatly riveted and soldered together and made water-tight. Cornice work shall be reinforced with properly-shaped steel brackets, separated from the copper by 3-pound sheet lead.

The top edge shall be formed over a heavy brass or bronze edge-strip or drip properly shaped to permit the joining of the top flashing or gutter-lining as specified elsewhere.

Ornaments shall be stamped in soft (roofing temper) copper with dies made from approved models.

Duplicate sets of detail drawings shall be submitted for approval.

51. Copper-covered Walls.

On vertical walls marked "Copper," such as bulkheads, skylight curbs, penthouse walls, etc., erect standing seam or paneled surfaces as indicated. All standing seam work shall be fastened to wall surfaces with cleats nailed with copper nails to wood sheathing, or furring strips. All paneled work shall have casings or strips to receive copper. Crimped sheets shall be used for all large panels and large areas of plain surfaces.

52. Cleaning Copper.

Except as otherwise specified all copper to be colored or painted shall first be thoroughly cleaned by scrubbing with a strong solution of caustic soda in hot water. After this solution has been applied the copper shall be washed off with clean water.

53. Coloring Copper.

(-1.) GREEN PATINA. After the copper has been scrubbed clean the following solution shall be applied: (1) One pound of powdered sal ammoniac to 5 gallons of water. Dissolve thoroughly and let stand 24 hours. Apply with a brush, covering every part. Let stand one day and then sprinkle with clean water; or, (2) one-half pound of salt to 2 gallons of water. Apply as for (1) above.

(-2.) BROWN OR BRONZE. Clean the copper of all foreign substances and debris and rub it thoroughly with waste soaked in boiled linseed oil until the desired color is obtained. Touch up solder with copper bronze.

54. Painting Copper.

All copper work to be painted shall first be scrubbed clean as specified elsewhere and coated with a wash composed of copper sulphate, 4 ounces to $\frac{1}{2}$ gallon of lukewarm water, and $\frac{1}{8}$ ounce of commercial nitric acid. This wash shall be applied with a brush, and allowed to dry. The copper shall then be dusted with a dry brush, and given one coat of red-lead-and-oil paint and two coats white-lead-and-oil paint, composed of 15 pounds of red lead to 1 gallon of raw linseed oil, with not more than $\frac{1}{2}$ pint of oil drier. All subsequent coats shall be composed of 15 pounds of white lead to 1 gallon of raw linseed oil with not more than 5 per cent. of oil drier and the necessary color to give the desired tint. All painting materials shall be of the quality specified under "Painting and Varnishing." Only those surfaces of copper work that will be exposed after installation shall be painted.

PART THREE

Notes on Copper Roofing

Copper possesses certain characteristics and physical properties which distinguish it from other metals used for roofing purposes. A thorough understanding of these is important.

The greatest difference is in expansion and contraction. Copper has a higher coefficient of expansion than has iron and steel, and a lower one than has zinc and lead. This means that for a given temperature variation there will be more movement in copper than in iron and steel and less than in zinc and lead. For example, in a range of 200° F., the movement in a sheet 96 inches long is:

	Inches	About
For Steel (Terneplate).....	0.1171	7/64
" Iron.....	0.1325	9/64
" Copper.....	0.1824	3/16
" Lead.....	0.3053	19/64
" Zinc.....	0.3322	1/3

Another difference is in malleability or ductility. Copper is the most ductile of metals used for roofings. This property of ductility allows copper to adjust itself to stresses due to temperature variations. Soft (roofing temper) copper is used for roofings and flashings because it possesses to the fullest degree this valuable physical property.

FUNDAMENTALS IN SHEET-COPPER ROOFING CONSTRUCTION

(There are a few fundamentals in applying sheet-copper roofing which cannot be over-emphasized. These are set forth in the ten rules listed below:)

RULE 1. Use 16-ounce soft (Roofing Temper) copper only.

- (a) Do not use hard (Cornice Temper) copper except for cornice work.
- (b) Do not use lighter than 16-ounce copper.

"SOFT" VERSUS "HARD" COPPER

Soft copper will give the most satisfactory results. Hard (cornice temper) copper, though sometimes used for flashings and roofings, is not

recommended. The soft sheet is, as can readily be understood, more easily workable, especially where bends, etc., are necessary.

THICKNESS OF COPPER SHEETS FOR ROOFS

It is not fair to a good material to use too thin a sheet. As copper does not corrode, there is no question of durability in the thinner gages. Copper sheet weighing 1 pound per square foot,

commonly known as 16-ounce copper, is considered the minimum standard sheet strong enough to withstand extraneous injury. Thinner sheets do not give the best results.

RULE 2. Prepare the laying surface carefully and see that it is smooth and even.

- (a) All copper sheets should be laid on rosin-sized paper or asbestos felt.
- (b) Sheathing boards should be ship-lap, tongued-and-grooved, or splined.
- (c) All nail heads should be set.

ROOFING BOARDS OR SHEATHING

It is recommended that ship-lap or tongued-and-grooved roofing boards be used. All roof sheathing should be well laid with even joints and secured at all bearings with heavy nails well set.

Immediately after laying, the sheathing should

be protected by covering it with paper as mentioned below. If possible the sheathing should be exposed to the weather at least 4 weeks before covering it with copper. The wood must be thoroughly dry and seasoned.

PAPER OVER SHEATHING

Good practice requires either the ordinary building paper or a rosin-sized or asbestos paper weighing about 6 pounds per 100 square feet.

On concrete roof slabs paper is not essential, provided the surface be made smooth and even as outlined on the following page.

CONCRETE ROOF SLABS

When copper is used over concrete the surface should be made smooth by a wash of neat cement. Elastic cement is sometimes used for this purpose.

Cinder concrete should not be used in contact with copper. Where copper is used in this type

of construction the concrete should be painted with a heavy coating of asphalt paint before the copper is applied.

Wood battens or expansion inserts must be set in the concrete for fastening the cleats.

RULE 3. Avoid sharp bends in copper sheets.

- (a) Do not crease the sheets or bend them more than 90 degrees.
- (b) Bend the sheets as little as possible before laying.

RULE 4. Allow for movement at intersections of roof planes by loose-locked joints.

- (a) Never carry a copper sheet over an angle more than 3 or 4 inches.
- (b) Break the sheet and lock it to the adjoining one by means of a loose- or double-locked joint. This allows room for expansion and contraction.

EXPANSION AND CONTRACTION

The temperature at the time the work is done must be taken into consideration by the contractor in allowing for expansion and contraction. A roof laid in July needs little room for expansion. It does, however, require ample provision for the

contraction which comes with cold weather. The reverse is, of course, true when a roof is laid in cold weather, and under these circumstances the contractor must be careful to provide ample room for movement.

RULE 5. Never nail copper sheets. Use cleats.

- (a) By "sheet" is meant any piece over 12 inches wide.
- (b) Use two-nail cleats $1\frac{1}{2}$ inches wide and place them not more than 12 inches apart.

RULE 6. Use copper nails only—never iron or steel.

- (a) Flat-head, wire "slating," or "shingle," nails are preferable.

CLEATS

Always secure the copper sheet by copper cleats, the cleats only being nailed to the roofing boards, the battens or wood ribs. Never use nails

of iron or steel to fasten copper at any place or under any circumstances. Galvanic action will quickly destroy the ferrous metal.

COPPER AND OTHER METALS

If possible, never use copper in contact with another metal, but if the plan of construction requires the use of iron or steel, by all means see that the iron or steel device is heavily tinned or

that sheet lead is inserted between the copper and the other metal. The use of brass devices is recommended, especially for gutter and eaves trough hangers.

RULE 7. Make full size joints and seams.

- (a) Standing Seams at least 1-inch finished.
- (b) Flat Seams (locked) at least $\frac{1}{2}$ -inch finished.
- (c) Lapped Seams at least 1-inch finished.
- (d) Double or copper-locked Seams at least $\frac{1}{2}$ -inch finished.

RULE 8. Tin carefully and thoroughly.

- (a) Use heavy tinning-coppers.
- (b) Use enough tin to cover all the surface.

RULE 9. Use rosin as a flux rather than acid.

- (a) If acid is used, see that it is properly and thoroughly killed.

RULE 10. Plenty of solder, well-flowed over, makes strong seams.

- (a) Use the best half-and-half solder and lots of it.
- (b) Heat the seam thoroughly.
- (c) Heavy, hot coppers are best for this.

WHITE LEAD

White lead in oil is a good substance for filling lock seams in copper work. It is simple to apply, is water-tight, and remains so a long time. White lead has been used on copper roofs, laid many years ago, both in this country and abroad. Notable among roofs of this type is that on the State House in Boston, Mass. This roof was laid in 1887-90 with leaded seams, and is apparently as tight today as it was thirty-five years ago.

The method of applying consists of smearing the edges of the sheets plentifully with white lead in oil and folding and locking them to form lock seams in the usual way. The viscous lead and oil completely fills the lock, making a water-stop.

White lead used in this way has much to recommend it. It is cheaper than soldering, and it is durable. On flat roofs where water backs up it is better to use solder, but on free-draining surfaces white lead can be used with every assurance of satisfaction.

The proper lead to use is that composed of basic lead carbonate and boiled linseed oil in paste form. It must be smooth and of putty-like consistency. Lumps will make uneven seams and prevent the locks from being completely filled.

After the seams have been locked and malleted all excess lead should be carefully removed from the sheets.

CLEANING

As soon as a portion of the roof is finished it should be carefully cleaned of all flux, scraps and dirt. Prominent signs should be displayed, where necessary, to prevent walking on the copper, and every reasonable precaution should be exercised to keep the roof free from all foreign substances,

such as mortar, scraps of lumber, paper, etc.

As the development of the characteristic green patina of copper is very much retarded by dirt, flux, etc., too much emphasis cannot be placed on thorough cleaning. Accumulation of dirt means uneven, splotchy coloring.

SLOPES OF ROOFS

The slope of roofs to be covered with flat seam copper roofing should not be less than $\frac{1}{2}$ inch nor more than 3 inches to the foot.

The slope of ribbed and standing seam roofs should not be less than 3 inches, and preferably 6 inches, to the foot.

FINISH

Copper will develop a beautiful patina in a few months due to natural phenomena. When it is desired to obtain this finish immediately, it can be done by the use of the following methods:

1. Clean the copper by washing it thoroughly with a strong solution of soda and hot water to remove the grease acquired in the process of rolling.

2. Apply the following solutions:

(a) 1 pound of powdered sal ammoniac to 5 gallons of water; dissolve thoroughly and

let stand 24 hours. Apply to copper with a brush, covering every part. Let stand one day and then sprinkle surface with clean water.

(b) Use a solution of $\frac{1}{2}$ pound of salt to 2 gals. of water. Apply in same manner.

3. A dark copper finish can be obtained by the following method: Rub off the copper with cotton waste soaked in boiled linseed oil. Touch up soldered seams with copper bronze.

PART FOUR

Sheet-Copper Facts

Copper is an excellent material for general sheet-metal purposes—particularly for roofing, eaves troughs, gutters, leaders, flashings, ridge rolls, ridge caps, leader heads, cornices, etc.

Its physical and chemical characteristics make

it an outstanding metal for long service under severe conditions.

As there are practically no maintenance costs its service value increases with age. It has a high salvage value.

DURABILITY

A copper roof will last for generations, probably for centuries. Numerous important buildings, as well as many fine residences, in the United States have copper roofs, some of them over 100 years old; in Europe and Asia are other examples which have lasted for centuries.

Perhaps the oldest copper work in the world

which is still in use is the Dragon weathervane on the Beffroi in Ghent, Belgium. This was erected in 1377 and is 548 years old.

The following is a partial list of copper roofs on prominent buildings located all over the world. Except in one case, St. Peter's Church in Rome, all of these roofs are in use today.

BUILDING	DATE	AGE
Nagoya Temple, Japan	1411	514
Temple of Heaven, Peking	1420	505
St. Peter's Church, Rome (Valley Flashings and Decks)	1503-1882	379
Bourse, Copenhagen, Denmark (Tower)	1619	306
Kronberg Castle, Helsingfors, Finland	(Circa) 1635	290
Christ Church, Philadelphia, Pa.	1758	167
Customs House, Dublin, Ireland (Dome)	1791	134
Drottningholm Castle, Lake Maiar, Sweden	(Circa) 1800	125
Chartres Cathedral, Chartres, France	1836	89
Dome of Capitol, Jackson, Miss.	1839	86
York Minster, York, England	1842	83
Madeline Church, Paris, France	1842	83
Trinity Church, New York, N. Y.	1846	79
Dome of Capitol, Boston, Mass.	1855	70
Dome of British Museum, London, England	1857	68
Opera House, Paris	1865	60
Pulitzer Building, New York, N. Y.	1889	36
Gripholm Castle, Lake Maiar, Sweden	1889	36
Chateau Frontenac, Quebec, Canada	1891	34
Temple Beth-el, New York, N. Y.	1892	33
Tower, Hackley School, Tarrytown, N. Y.	1900	25
West Street Building, New York, N. Y.	1906	19
Cathedral of St. John the Divine, New York, N. Y.	1907	18
Grand Central Terminal, New York, N. Y.	1912	13
Woolworth Building, New York, N. Y.	1912	13

Copper retards appreciably the corrosive action of acid fumes, and is a most effective material for use under extreme atmospheric conditions such as

are found in manufacturing localities and cities. Near the sea coast and in country districts its durability is unquestioned.

APPEARANCE

The green coating or patina which appears on copper after exposure to the atmosphere not only acts as a shield against deterioration, but also

makes it a most beautiful roofing material. It does not require painting or special protective treatment of any kind.

WEIGHT

The non-corrosive properties of copper make it possible to use a thin sheet, and its comparative lightness permits its use in construction work without the necessity of heavy supporting struc-

tures. It is one of the lightest of roofings.

The weights of various roofing materials per square (100 square feet) on the roof are as follows:

MATERIAL	WEIGHT OF 100 SQ. FT. LAID
Shingle Tile.....	1200-1800 lbs.
Spanish Tile.....	650- 850 "
Slate.....	450- 675 "
Felt and Gravel (or Slag).....	400- 625 "
Asbestos Shingles.....	300- 650 "
Hardlead Sheets.....	210- 325 "
Wood Shingles.....	200- 300 "
20 g. Galv. Iron (Corrugated).....	225 "
16 oz. Copper (Standing Seam).....	125 "
Copper Shingles.....	84- 100 "
Tin.....	75 "

MALLEABILITY

Copper is one of the most ductile of metals. No other is more easily worked or so permanent when formed. This is a decided advantage in

working with copper, as the "brittleness" which renders some other metals difficult to handle is not present.

ECONOMY

Freedom from repairs or maintenance expense, combined with durability, makes copper one of the most economical and best roofing materials obtainable.

First cost is the only expense involved in the

use of copper for building purposes. It has a higher salvage value than any other metal used for building purposes. Being indestructible, it can be salvaged from any building destroyed and will always sell for a reasonable figure.

COPPER SHINGLES

Another form of copper roof covering is copper shingles. These are made from hard-rolled copper sheets in a variety of sizes and designs. The method of application is simple. They are secured to the roof sheathing by copper nails at the top. Each shingle locks with adjoining ones to form a water-tight joint. No soldering is required. No allowance for expansion is necessary as the lock provides room for movement.

Copper shingles can be laid equally well on new roofs and over old shingled roofs. Because of their raised-butt construction they are lifted slightly, thus providing an air space between the shingle and the roof sheathing, allowing ample ventilation with consequent coolness in summer.

Copper shingles are light. A roof so covered weighs only one-ninth as much as slate and one-third as much as wood.

Memoranda

